Community Wildfire Risk: a structure ignition problem

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Available research reveals opportunities to potentially prevent disastrous community destruction of homes and other structures during extreme wildfires. By creating structure ignition resistance and collectively, ignition resistant communities, we can effectively prevent wildland-urban (WU) fire disasters without using wildfire suppression that is inconsistent with sustaining wildfire adapted ecosystems (the “wildfire paradox”), and fails during extreme wildfire conditions when WU fire disasters occur (Calkin et al. 2014; Law et al. 2023).

Patterns of Home Destruction during Wildfires

Unconsumed vegetation post-fire, often remaining green, adjacent to and surrounding destroyed homes is the typical WU fire pattern associated with extreme wildfire conditions (Cohen 2000b; Cohen and Stratton 2003; Cohen 2003; Cohen and Stratton 2008; Graham et al. 2012; Cohen 2017; Westhaver 2017; Cohen and Westhaver 2022). The three photos (Figure 1) of home destruction with adjacent unconsumed shrub and tree vegetation indicate the following:

- *High intensity wildfire did not continuously spread through the residential area as a sweeping wave of flame.*
- *Unconsumed shrub and tree canopies adjacent to homes did not produce high intensity flames that ignited the homes.*
- *Homes could have only ignited from lofted burning embers directly contacting the home, low intensity surface fire flames and smoldering contacting the home, and in high density development, structure-to-structure fire spread.*
- *The “big flames” of high intensity wildfires did not cause total home destruction.*

Paradise, CA; 2018 Camp Fire **Southwest CO; 2002 Missionary Ridge Fire** **S Cal; 2007 Grass Valley Fire**

Figure 1.Destroyed homes interspersed with and adjacent to unburned, green, vegetation.

Wildfires occurring in continuous vegetation during severe weather (strong winds and low relative humidity) can produce extreme wildfire behavior in grass, shrub and forest fuels that overwhelms wildfire suppression and control. Extreme wildfire approaching a community can initiate multiple, simultaneous ignitions of structures, vegetation and other combustible materials within the community. Subsequently, the burning structures and vegetation continue the community fire spread and destruction for hours after wildfire influence has ceased (Cohen and Stratton 2008; Cohen 2010; Cohen and Westhaver 2022).

Local Conditions Determine Structure Ignitions – the Home Ignition Zone (HIZ)

Local conditions determine the structure ignitions that can lead to disastrous community fire destruction during extreme wildfire conditions (Cohen 2004). The wind-blown burning embers, high burning intensities and rapid fire spread and growth rates of extreme wildfire conditions do not directly determine home and structure ignition potential. A home's (structure's) ignition vulnerabilities in relation to its immediate surroundings within 30 meters principally determine a home's (structure's) ignition potential. This area, called the *home ignition zone* (HIZ, Cohen 2001; Finney and Cohen 2003; Cohen 2010; Calkin et al. 2014; Westhaver 2017; NFPA 2018; Cohen and Westhaver 2022) defines WU fires as a structure ignition problem that is not directly related to wildfire intensity and geographical classifications (e.g. "interface," "intermix," etc.). Hence, the dropping of the term "interface" (WUI) when identifying wildland-urban (WU) fire.

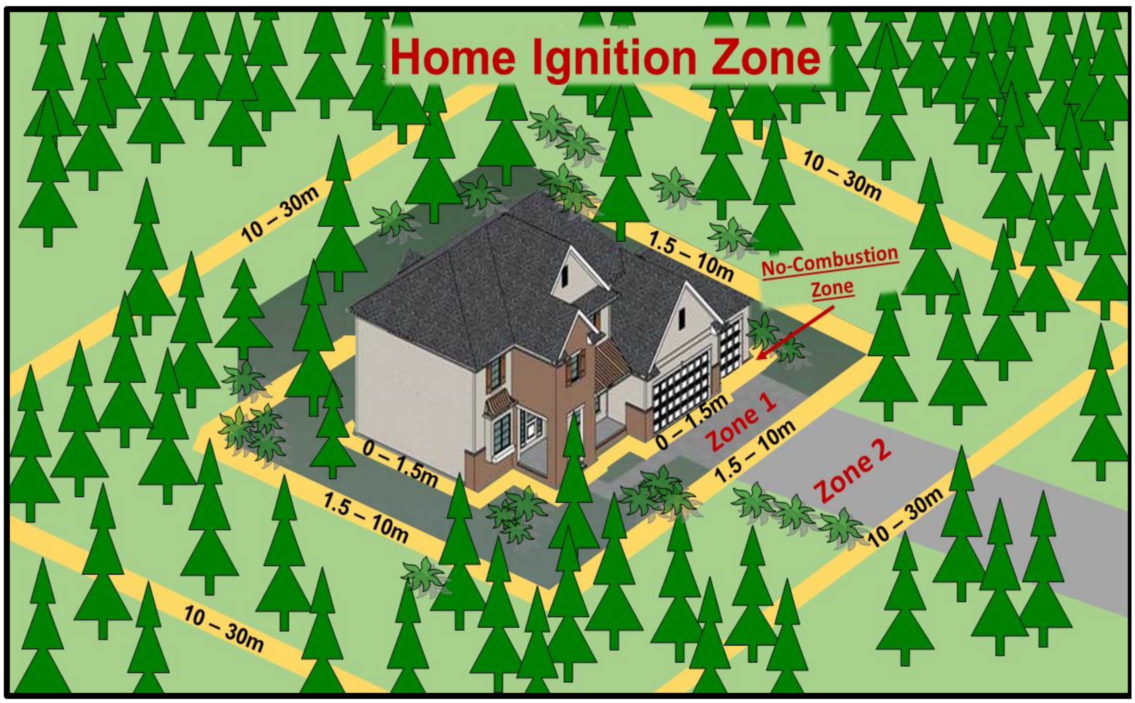

Figure 2. The ignition vulnerabilities of the structure in relation to burning embers and burning materials in the No-Combustion Zone, Zone 1 and Zone 2 comprise a general description of the HIZ.

An ignition resistant HIZ, the primary structure in relation to its surroundings with 30 meters, will have the general characteristics described as follows (Fig. 2):

Surrounding Zones within 30 meters of the primary structure

- The HIZ does not support high intensity fire spreading through or developing within the HIZ; high intensity wildfire ceases within Zone 2 if spreading toward the HIZ from vegetation and structures;
- Zones 1 and 2 can have low intensity surface fire; importantly however, burning materials within Zones 1 and 2 cannot produce flame contact with, or long duration radiation exposures (from other structures, woodpiles, fences, etc.) to, the primary structure;
- The No-Combustion Zone does not support any sustained smoldering or flaming combustion within 1.5 m of the primary structure and its flammable attachments;

- Thus, burning embers from the wildfire and burning community fuels become the only source of ignition to the primary structure;

Primary structure

- Class A fire rated roof covering does not ignite or support flame spread (nearly all but a flammable wood roof covering);
- The structure materials and design features resist sustained ignitions from all burning ember sources, wildfire and burning community structures and vegetation;
- Noncombustible materials are used/installed in locations where burning embers accumulate (for example, at horizontal-to-vertical intersections such as at ground-to-wall, deck-to-wall and roof-to-wall locations);
- Openings to any interior spaces are covered with ember and flame-resistant venting, screening and other covering methods;
- Flammable debris (vegetative litter) and materials (fire wood, lumber, furniture, etc.), have been removed from locations of burning ember exposure, such as on roofs, in rain gutters, on decks, and under and within 1.5 meters of flammable components such as decks, board walks, stairs, and fencing.

How Disastrous Community Fire Destruction Occurs

We have defined a WU fire disaster as one-hundred or more totally destroyed homes and other structures for the purpose of analysis (Cohen 2010; Calkin et al. 2014). Significantly, WU fire disasters have only occurred during extreme wildfire conditions when wildfire suppression has failed and communities were exposed (Cohen 2010; Calkin et al. 2014). Although wildfires did not spread through these communities, the uncontrolled, extreme wildfires initiated numerous, virtually simultaneous ignitions across a broad community area. The extreme wildfire conditions resulting in overwhelmed fire suppression included fires burning in grass and light shrubs, California chaparral or conifer forest. After initiating ignitions, the community's vulnerability to ignitions and community fire

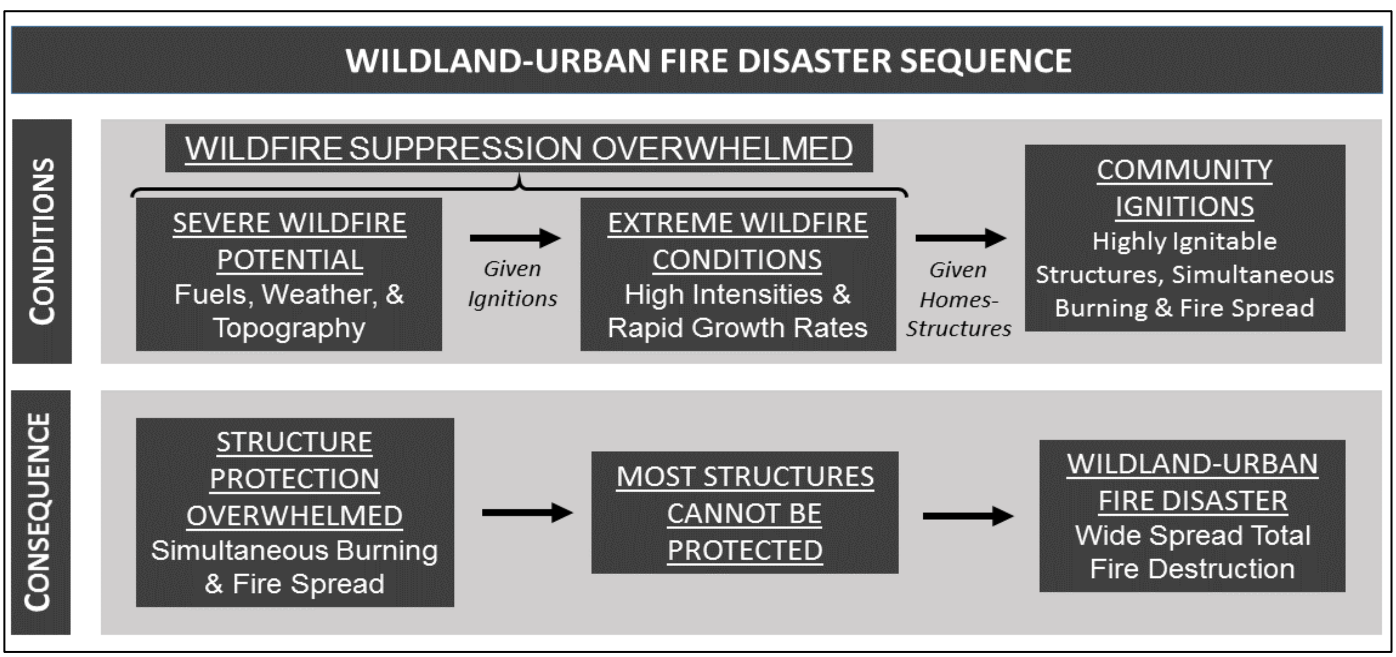

Figure 3. WU disaster sequence. Each box corresponds to a factor that critically contributes to high numbers of destroyed homes during a WU fire. Note that, if structures are ignition-resistant and numerous structure ignitions do not occur (3rd "Condition" factor), structure protection effectiveness can increase sufficiently (first 2 "Consequence" factors) to prevent disastrous losses (final "Consequence").

spread determined the amount of fire destruction; community fire destruction was not directly related to wildfire intensity (Cohen and Stratton 2008; Cohen 2010; Westhaver 2017; Cohen and Westhaver 2022). For example, each of the following wildfires principally burning in grass, shrub or conifer forest fuels, initiated ignitions resulting in WU fires with thousands of destroyed homes:

- 2020 Almeda Drive (OR), and 2021 Marshall Fire (CO) -- Grass and light shrubs;
- 2017 Tubbs (n. CA) and 2018 Woolsey (s. CA) Fires -- California chaparral;
- 2018 Camp (n. CA), 2021 Caldor and Dixie (n. CA) Fires -- Conifer forest

The above discussion (patterns of destruction and local ignition conditions) indicates WU fire disasters depend on exposed communities igniting and continuing community fire spread independently of a wildfire. Wildfires will be inevitable, and that means extreme wildfire conditions will be inevitable with wildfire suppression overwhelmed (Fig. 3, first two "Condition" factors). These are the target conditions of WU fire disasters. Given an extreme wildfire exposure, the "Community Ignitions" factor (Fig. 3, third "Condition" factor) principally determines whether or not the WU fire disaster occurs (final "Consequence"). Thus, creating and maintaining sufficiently ignition-resistant structures, and collectively, communities (Fig. 3, third "Condition" factor) can prevent WU fire disasters by eliminating most ignitions and thereby enabling effective structure protection (Fig. 3, first and second "Consequence" factors). The WU fire disaster (Fig. 3, final "Consequence") can be averted without necessarily controlling the wildfire (Cohen 2000a; Cohen 2001; Cohen 2004; Cohen and Stratton 2008; Cohen 2010; Calkin et al. 2014; Cohen 2017; Westhaver 2017; Cohen and Westhaver 2022).

Community Wildfire Risk Analysis: Defining an effective approach

Reducing community wildfire risk must address the risk factors that principally determine structure ignitions that can be effectively and practically mitigated (Calkin et al. 2014). Framing WU fire disasters in terms of strategic risk management (Calkin et al. 2014) conceptually defines the primary risk factors as the <u>wildfire exposure</u> (hazard), <u>structure ignitions</u> (response), and <u>structure protection</u> (effectiveness).

<u>Wildfire exposure factor</u>: Community wildfire risk cannot be reliably reduced by addressing wildfire. Estimating and addressing potential wildfire intensity exposure to a community ("Wildfire Risk to Communities;" https://www.fs.usda.gov/managing-land/fire/wildfirerisk) will not reliably reduce community wildfire risk for the extreme wildfire target conditions. As discussed above, community wildfire risk is not directly related to wildfire intensity and the inevitability of uncontrolled extreme wildfire means the wildfire hazard to communities cannot be managed for effective risk reduction. Thus, WU fire disasters need to be defined as a structure ignition and community fire spread problem, not an extreme wildfire problem. However, determining community wildfire exposure potential can be useful for setting community priorities to reduce WU fire risk (Menakis et al. 2003).

<u>Structure ignition factor</u>: The above discussion explained how local HIZ ignition conditions determine structure ignitions; thus, mitigating the numerous critical HIZ ignition factors becomes the most effective and practical approach for reducing community wildfire risk. In developments with high structure density, overlapping, shared HIZs does not change ignition requirements, but does require property owners within a community to share responsibility for mitigating the collective wildfire risk (Finney and Cohen 2003). Importantly, structure ignition resistance does not mean a "fire proof" structure. Although an ignition resistant HIZ will eliminate most ignitions, the potential for a sustained ignition remains and requires someone to extinguish ignitions. At high structure densities, reducing the risk of community fire spread (urban conflagration) will also require mitigations to eliminate and slow community structure-to-structure flame spread.

<u>Structure protection factor</u>: Ignition and fire spread resistant communities do not eliminate the need for fire protection. As indicated by the "Disaster Sequence" (Fig. 3), community wildfire risk reduction will require sufficient ignition and fire spread resistance to enable effective community structure protection (Fig. 3, first and second "Consequence" factors).

Effective WU Fire Disaster Prevention Requires a Paradigm Change

The above description of how structures ignite and how WU fire disasters occur with the analysis of community wildfire risk does not support the current framing of community wildfire risk as a wildfire behavior and control problem. The continued definition and approach of WU fire as a wildfire problem will continue the inevitability of WU fire disasters (Calkin et al. 2014). Alternatively, this analysis indicates WU fire is a structure ignition and community fire spread problem where effective mitigation occurs within HIZs and collectively, the community (Finney and Cohen 2003; Cohen 2010; Cohen and Stratton 2008; Calkin et al. 2014; Westhaver 2017; Cohen and Westhaver 2022).

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